



Hydrogen-Oxygen Bottle Rocket

Written By: Tom Zimmerman



TOOLS:

- [Deep sink or outdoor hose \(1\)](#)
- [Drill bit 1/8" \(1\)](#)
- [Fine-tooth Saw \(1\)](#)
- [Hammer and nails \(1\)](#)
- [Metal ruler \(1\)](#)
- [Protective eyewear \(1\)](#)
- [Razor blade knife \(1\)](#)
- [Sharpie marker Black \(1\)](#)
- [Soldering iron solder \(1\)](#)
- [Wire cutter/stripper \(1\)](#)



PARTS:

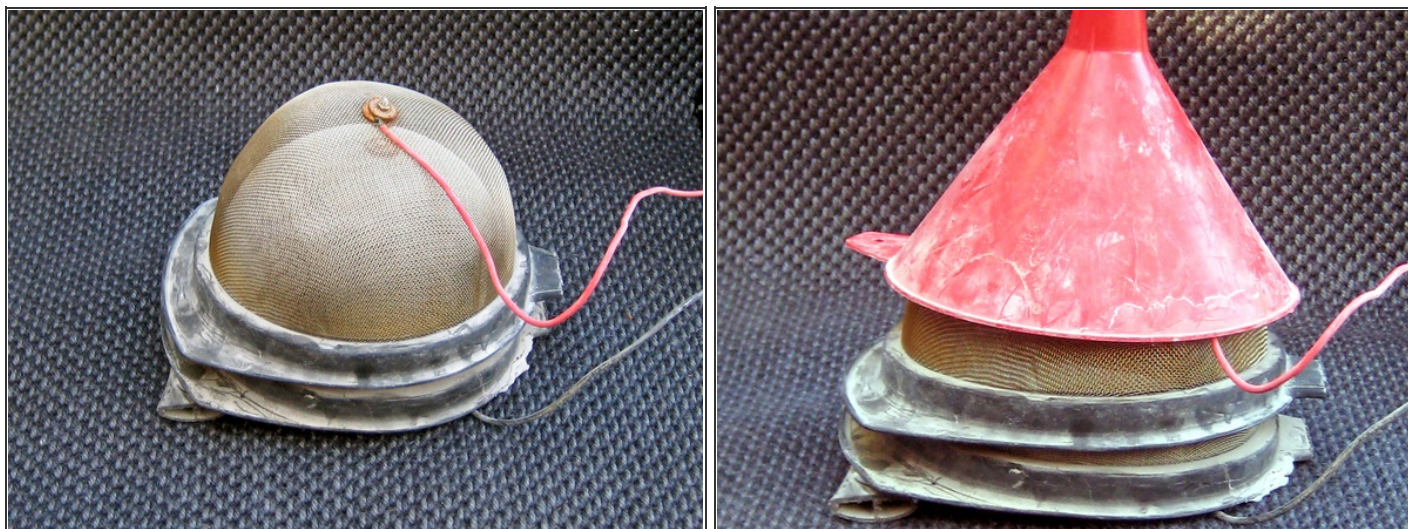
- [9V battery snaps \(2\)](#)
- [2-liter soda bottles \(2\)](#)
- [Corrugated plastic 4" x 6" \(3\)](#)
- [Wooden dowel 1/4" diameter 36" long \(3\)](#)
- [Wooden dowel 3/8" diameter 36" long \(6\)](#)
- [Pine boards 11" x 11" x 3/4" \(2\)](#)
- [Insulated solid-core wire 20 to 24 gauge 10' \(1\)](#)
- [Insulated speaker wire 16 gauge 20' \(1\)](#)
- [Vinyl tubing 3" length that slips over 1/4" dowel \(1\)](#)
- [Sealable lightweight plastic mini container \(1\)](#)
- [Clear silicone sealer \(1\)](#)
- [Pencil with eraser \(1\)](#)
- [Heavy rubber bands \(3\)](#)
- [Electrical Tape \(1\)](#)
- [Scrap of foam rubber \(1\)](#)
About 4" square

- [9V Alkaline batteries \(2\)](#)
[One for testing and one for launch](#)
- [4 one-hole rubber stoppers \(2\)](#)
- [Estes Model Rocket igniters \(1\)](#)
[Package of 6](#)
- [IC PC board \(1\)](#)
- [Alligator clips \(4\)](#)
- [12V flashlight bulbs \(2\)](#)
- [8-pin socket \(1\)](#)
- [14-pin socket \(1\)](#)
- [4017 counter decoder IC chip \(1\)](#)
- [N-channel MOSFET transistors \(2\)](#)
[Jameco #209058](#)
- [555 timer IC chip \(1\)](#)
- [Mini single-pole switches \(2\)](#)
- [3mm red LED's \(2\)](#)
- [3mm green LED's \(2\)](#)
- [Resistors 100Ω \(2\) 1KΩ \(6\) 10KΩ \(1\) \(1\)](#)
- [Variable resistor \(Potentiometer\) 1MΩ \(1\)](#)
- [Capacitor 0.01uf \(1\) 1uf \(1\) \(1\)](#)
- [Oxo brand 8" Strainers \(2\)](#)
- [8" plastic funnel \(1\)](#)
- [Heavy-gauge wire \(1\)](#)
[20'](#)
- [5gal bucket \(1\)](#)
- [Large box of baking soda \(1\)](#)
- [12V car battery charger \(1\)](#)
[10 amps minimum](#)
- [8-32 1 2" bolts \(2\) 8-32 nuts \(2\) 8-32 1" washers \(6\) \(1\)](#)

SUMMARY

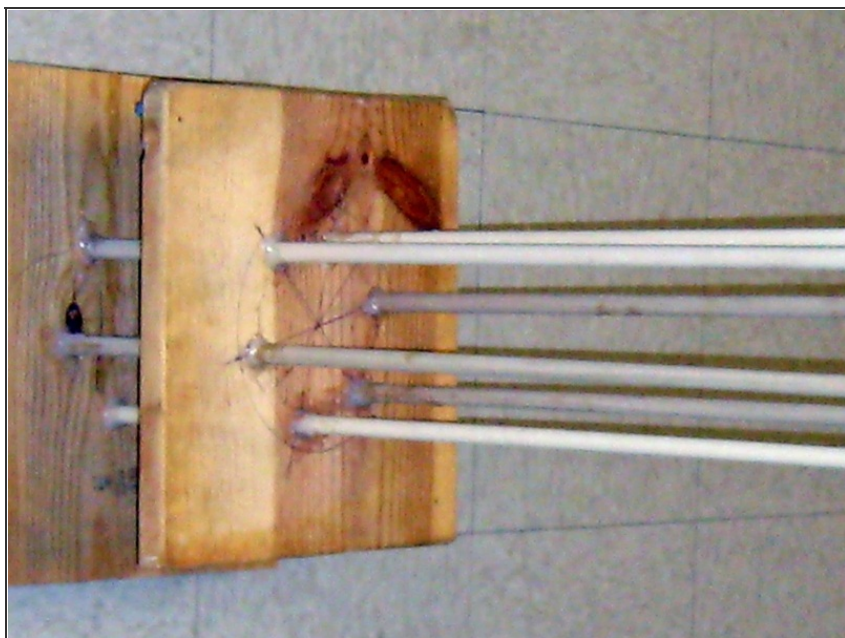
Air-powered water rockets are easy to build and the fuel is free, but do you want to push the envelope? How about a two-stage water rocket? And instead of pressurized air, how about an explosive gas? I know the perfect gas to use. Back in high school chemistry, I learned about the electrolysis of water, using electricity to break water molecules into hydrogen and oxygen gases. A spark recombines the elements back into water, releasing energy that vaporizes the water. The hot water vapor causes a rise in pressure, and in this project we use this pressure to push water out of the soda bottles and propel the rocket upward. This rocket is controlled by an onboard timer circuit that runs off a 9-volt battery and ignites the gases electrically using model rocket igniters. The circuit's variable resistor lets you precisely time the interval between first- and second- stage ignitions to attain maximum height. LED firing signals provide a visual countdown, and when the gases ignite they produce a delightful explosion.


Step 1 — Prepare the gas generator.



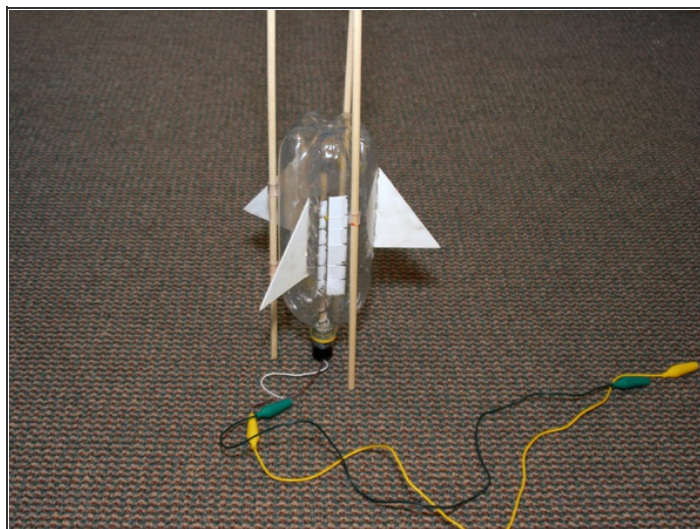
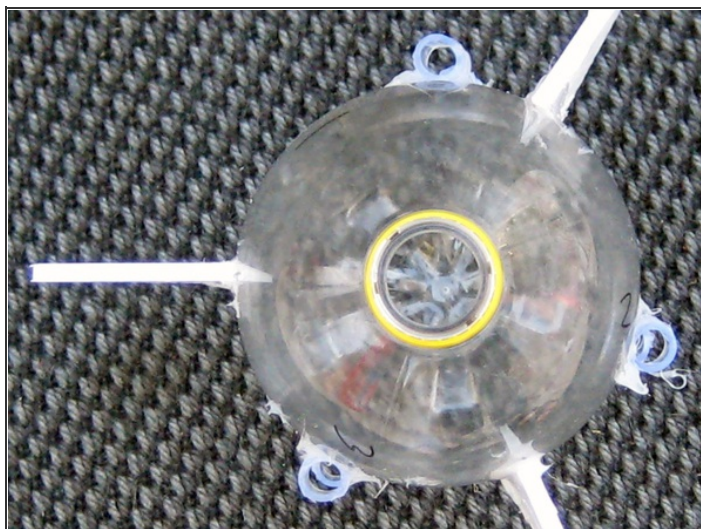
- Cut the handles off the strainers.
- Using a nail, separate the mesh at the top of each strainer just enough to make room for the bolt.
- Place a washer on a bolt and pass it through the hole in the strainer. Place a second washer on the bolt, wrap a heavy-gauge wire around the bolt, place a third washer on top of that, and tighten it down with a nut.
- Repeat with the second strainer, mounting the bolts in opposite directions so they won't touch when the strainers are stacked together.
- Stack the strainers and glue the rims together with silicone sealer. The Oxo brand strainers have a plastic rim so the metal mesh won't touch when they're stacked; if you use different strainers you'll need to glue foam insulation between the strainers.
- Glue the rim of the bottom strainer to the inside bottom of the 5gal bucket with silicone sealer.
- Place the funnel on top of the upper strainer. Notice where they touch, and place a few drops of glue.

Step 2 — Build the launch pad.



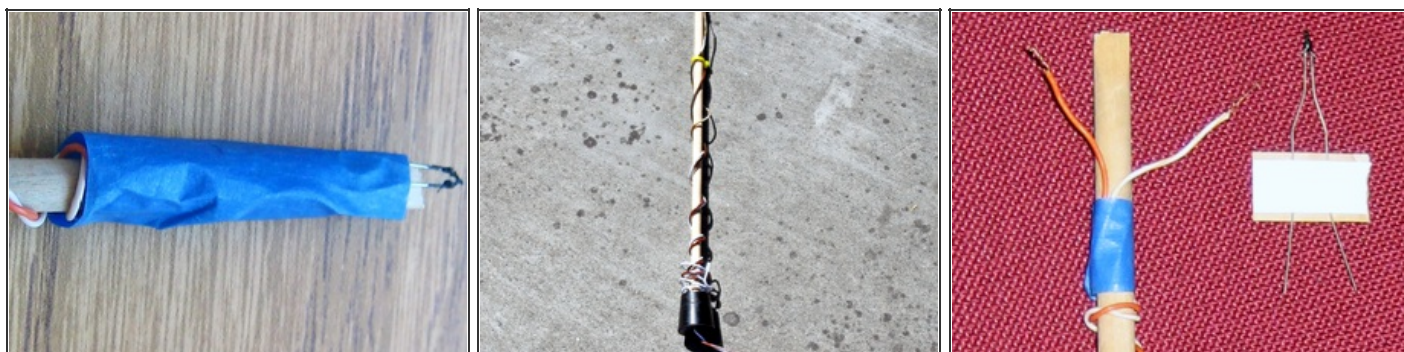
- The launch pad can also hold the rocket during construction. 
- Stack the 2 pinewood boards and clamp them securely, or nail them together temporarily with 2 nails in opposite corners.
- Draw a circle whose diameter is $\frac{1}{2}$ " larger than the diameter of the plastic bottle, centered on the top board.
- Drill six 2" holes evenly spaced (60° apart) on the circle.
- Unclamp or remove nails, and shove the 2" dowels through the holes, flush to the bottom of the bottom board. Slide the top board 6" above the bottom board.
- Glue the dowels into the holes with silicone sealer.

Step 3 — Build the rocket.



- Cut 6 fins from the corrugated plastic using the razor blade and metal ruler.
- Mark 6 evenly spaced lines (60° apart) on the side of each plastic bottle.
- Glue 3 fins evenly spaced (120° apart) on the bottom of each bottle (the end with the nozzle) with the 4" side vertically against the bottle.
- Cut six $\frac{1}{2}$ " pieces of vinyl tubing and glue them to the bottom and middle of one bottle, 120° apart between the fins. This will be the upper stage.
- Glue three $\frac{1}{4}$ " dowels 18" long to the sides of the other bottle, 120° apart between the fins, starting halfway up the bottle. Use the launch pad to hold the rocket during construction. Use 3 rubber bands to hold the dowels in place while the glues dries. This will be the lower stage.

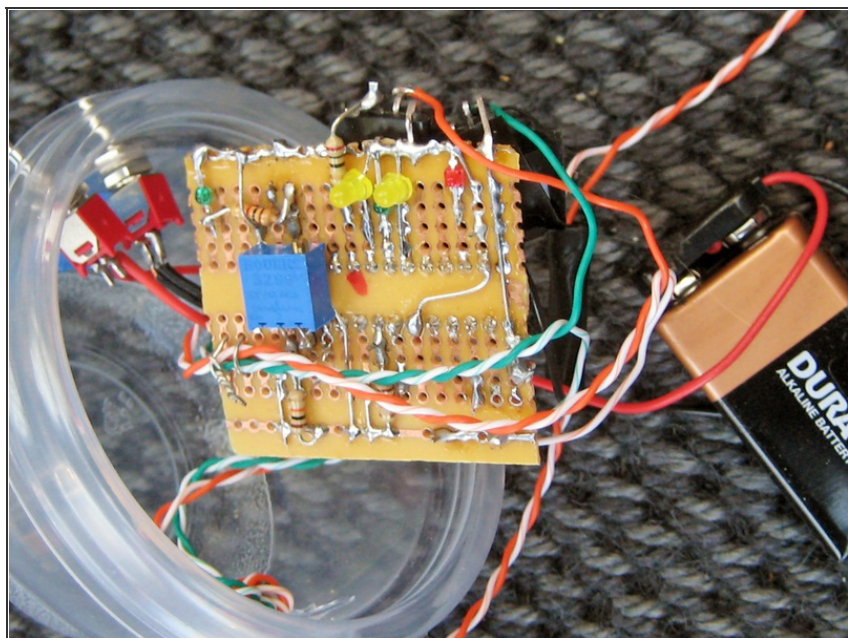
Step 4 — Make the igniters.



- Prepare each igniter carefully because if it doesn't fire, the rocket stage won't ignite.
- Cut a wedge into one end of the 10"-long $\frac{1}{4}$ "-diameter dowels. Cut 2 feet of twisted wire, align the wire with the wedged edge of the dowel, and tape the wire 1" below the end of the dowel. Wrap the wire around the dowel, pass the excess through the rubber stopper hole, and then pass the other end of the dowel through the rubber stopper hole.
- Strip the ends of the wire taped to the dowel with a razor blade or knife, twist them to the leads of a rocket igniter, and tape them to the wedge with the chemical tip exposed.

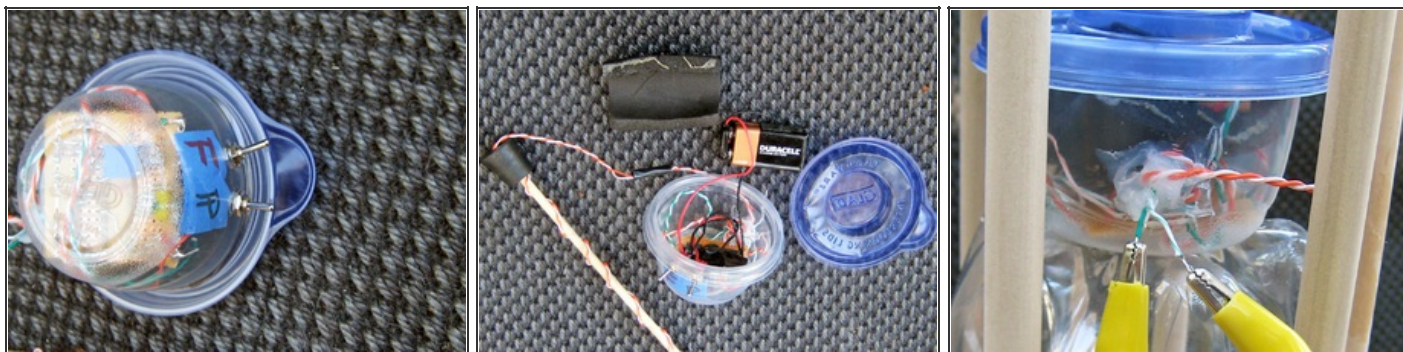


Step 5 — Assemble the stage sequencer electronics.



- Use a pencil eraser to clean all the copper on the circuit board.
- Solder the sockets in place, then the components. For all electronics connections, refer to the schematic diagram that is attached to this guide
- Put all the LEDs on the same side so you can see them through the plastic case. Put tape around each transistor to make sure they don't touch. Install the 555 and 4017 chips after all soldering is complete.
- Check your wiring, then power up the circuit. If the oscillator LED doesn't flash, turn off the power and check your circuit.




Step 6



- For testing, install 2 flashlight bulbs in place of the igniters. Make sure they fire in sequence.
- Drill 2 holes in the plastic container for the switches and 1 hole for the igniter wires. Cut the lower stage ignition wires 4" long and solder alligator clips to the end. Cut the upper stage ignition wires 2" long and solder alligator clips to the ends. Seal the igniter wire hole with silicone.
- Stuff the electronics, battery, and a piece of foam padding into the case.
- Glue the electronics case onto the top of the first stage. This is where you'll clip the electronics to the igniters before launch.

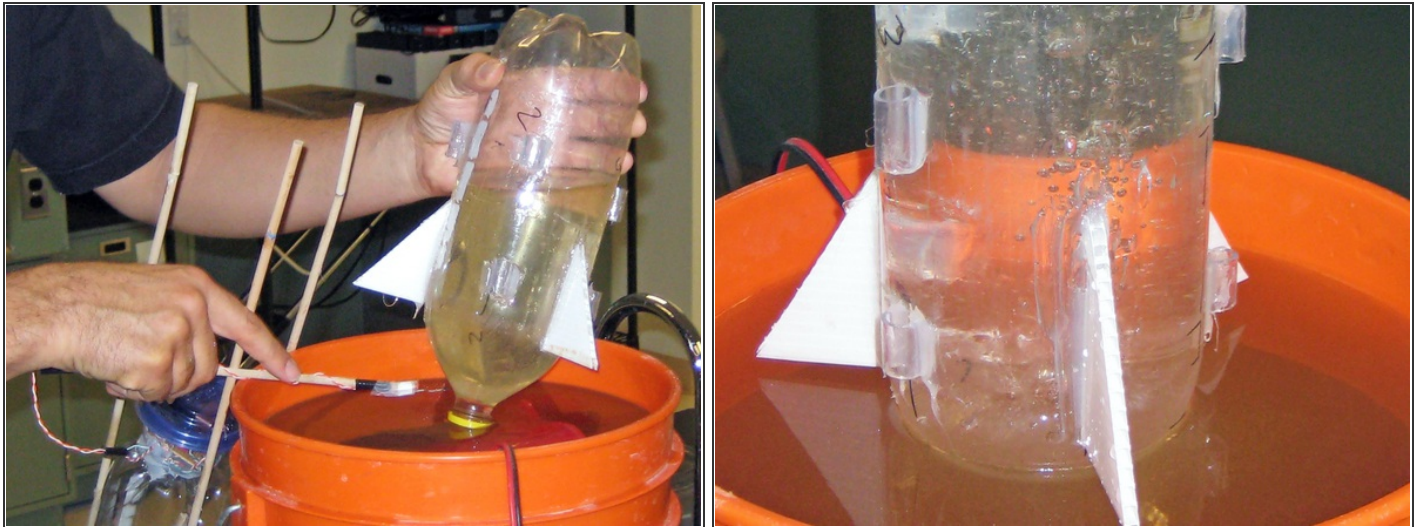
Step 7 — Generate the gas.




- Two people are required when making the gas; one with dry hands controlling the power supply, the other handling the rocket in the water. 
- **CAUTION:** This step involves a shock hazard. Responsible adult supervision is required. 
- Put the gas generator assembly in the bottom of the 5gal bucket, with the wires running outside the bucket.
- Fill the gas generator bucket with warm water so the top of the funnel is completely covered (about 5 gallons). Mix in baking soda based on the current capacity of your battery charger; 15 grams for 10 amps, 80g for 20A, 110g for 30A, and 160g for 40A.
- Attach the wires to the battery charger and plug in the charger. You should see bubbles coming out of the funnel.
- **SAFETY WARNING:** Never put your hands in the water when the battery charger is plugged into the wall! Even if the charger is off, you could get electrocuted. The gas mixture you are generating is explosive; operate in a well-ventilated place (outside is ideal) away from any flame or source of ignition. Wear 

safety goggles, and again, keep the power supply unplugged when anyone's hands are put into the water.

Step 8 — Fill the rockets.



- We use a technique called water displacement to fill each bottle with explosive gas. 
- Fill the bottle with water. With the battery charger unplugged, cover the end of the bottle, submerge it in the water, and place it over the funnel nozzle.
- Plug in the charger and fill the bottle 1/3 with gas.
- Unplug the charger, put a cap on the bottle while it's still underwater, and remove the bottle from the bucket.
- Do the next step outside or over a sink because it's going to get wet. Remove the cap and quickly insert the igniter into the bottle. Don't crush the igniter against the bottle. Let enough water leak out so the bottle is 1/4 filled with water, then press in the rubber stopper to stop any leak.

Step 9 — Optimize the ignitions and fine-tune the fuel mix.



- The time between the first and second stage ignitions, determined by the clock rate of the 555 timer, can be optimized. Fire Stage 2 too soon and the full energy of Stage 1 will be wasted; fire it too late and the rocket will be decelerating or, worse, might not be pointing up! Adjust the ignition timing with a twist of the potentiometer. If the rocket starts curving back to Earth before Stage 2 fires, decrease the variable resistance to speed up the sequence rate (the flashing green LED). And if Stage 2 fires too quickly, increase the variable resistance to slow down the sequence rate.
- The ratio of gas, water, and air is crucial for attaining the highest flight. The air dilutes the HHO gas to limit the pressure; use too much gas and the bottle will explode. The water provides mass to push against; use too much water, and the rocket will waste energy lifting extra water. In my first attempt I used $\frac{1}{3}$ gas, $\frac{1}{3}$ air, and $\frac{1}{3}$ water. Start with this ratio. Later you can try filling with $\frac{1}{2}$ gas and $\frac{1}{3}$ water, which will leave $\frac{1}{6}$ for air. If your bottle explodes, use less gas and more air.
- You can determine the optimum ratio by strapping a bottle to a free-standing bicycle wheel, as shown

here. Ignite the engine with the bottle upright at the 9 o'clock position (temporarily held in place with a stick). Time how long the wheel turns after ignition to get an idea of the power of the engine. More accurate results can be obtained using an electronic force gauge (please post what you learn at makezine.com/20/hhorocket).

Step 10 — Fire in the hole!



- Place the launch pad on flat, hard ground. Connect a fresh alkaline battery and assemble the rocket on the launch pad. Don't hook up the igniters yet. Carefully attach the igniter leads. Keep the alligator clips separated to avoid a short. The rocket is now armed and dangerous.
- To launch, close the ARM switch and make sure the green sequence rate LED is flashing about once per second. Make sure the launch area is secure, close the FIRE switch (you'll see the yellow sequence LED go on), then run away from the pad. The rocket should blast off in seconds! If after 1 minute the rocket doesn't take off, walk back cautiously and turn off both switches. Drain all the water, turn the rocket upside down to release the hydrogen gas, and figure out what went wrong.
- You can reuse the bottles; just re-glue fins or dowels that break on landing. For softer landings, add a parachute. To improve aerodynamics and increase flight height, add a nose cone. Also try using wider, taller fins with their shape cut to follow the curve of the bottle at the bottom; our 3"×4" fins are small. Increase the proportion of gas to make the rocket more potent. At some point the bottle will

rip; you can test a bottle on its own to determine this limit.

- If you're ambitious you could try 3 stages, or several first stage boosters wired in parallel to 1 transistor to fire simultaneously (you might need 2 batteries in parallel to get enough current).
- Here's a good reference on building water rockets:
home.people.net.au/~aircommand
- Here's a movie of my first launch:
<http://www.makezine.com/go/hho>

This project first appeared in [MAKE Volume 20](#).

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